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Quantitative aspects of the feeding activity of some oribatid mites (Oribatida, Acari) in an alpine meadow ecosystem

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With 2 figures

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1. Introduction

An alpine meadow ecosystem (2,550 m above sea level), representing the vegetation type Caricetum firmae Kerner (Br.-Bl. 1926) has been studied in the Schweizerischer Nationalpark since 1976 in an interdisciplinary research project (Matthey *et al.* 1981).

The alpine meadow consists of a quite heterogeneous pattern. Small patches of vegetation with an average area of about 0.5 to 2 m^2 are partly separated from each other by bare soil zones. Within the patches several vegetation types can be distinguished by their dominant plant species. The sedge *Carex firma* Host, or *Dryas octopetala* Linné (Rosaceae), or *C. firma* and the grass *Sesleria coerulea* (Linné) Ard. may be dominant. Dead leaves of grasses and sedges remain in contact with the living parts of the plants for more than 10 years (Galland 1982).

For energy flow and nutrient cycles of terrestrial ecosystems microarthropods are jointly responsible as regards the following main performances:

(1) Macrophytophagous species (after Luxton 1972) degrade the accumulated higher plant residues, thus increasing leaf surface (e.g. Berthet 1964). (2) Panphytophagous species feed on plant materials as well as on microorganisms. (3) Microphytophagous species feed exclusively on microorganisms. Dispersal of microorganisms via faeces or on the bodysurface is another positive effect (Mignolet 1971, Cervec 1976). In consequence, all kinds of microarthropods stimulate and also catalyze microbial activity (Luxton 1984).

The efficiency of metabolism, e.g. the relation between the assimilated material and the ingested food may depend on the fresh mass, the systematical position and the feeding behaviour of a species, but also on abiotic factors, for example on temperature (Krebs 1972, Streit 1980).

There are few publications describing feeding activities of microarthropods in alpine ecosystems (Schatz 1978, Schatz 1979, Schatz 1981, Reutimann *et al.* 1984, Rohrer & Reutimann 1984). Quantitative aspects are poorly understood. Many species have a lower fresh mass compared to related lowland species. Short vegetation periods, heterogeneous plant associations and low average temperatures may be dominant factors responsible for a completely different situation compared to all lowland and subpolar ecosystems.

It was the aim of the present study to investigate these quantitative aspects of the feeding behaviour of the important oribatid mite species *Phthiracarus borealis* (Trägårdh, 1910), *Nothrus borussicus* Sellnick, 1929, *Protoribates cf. longior* Berlese, 1910, and *Damaeus diversipilis* (Willmann, 1951) in the laboratory as well as in field experiments under seminatural conditions.

2. Methods and materials

Egestion rates (faeces and urine are excreted together, comp. Madge 1964) were used as a basis for estimates regarding energy budgets (Thomas 1979, Mittmann 1980).

Table 1. Experimental conditions

Species	Type of vessel	Individuals per vessel	Food	Temperature [°C]
P. borealis	clay	2	leaves	5, 10, 15, 20, 15/5
N. borussicus	clay	2	leaves	5, 10, 15, 20
P. cf. longior	clay	10	leaves	5, 10, 15, 20, 15/5
D. diversipilis	plastic/ charcoal	10	8 fungi	5, 7.5, 15, 17.5, 20 15/5 °C daily alternating temperatures (comp. text)

Individuals of *P. borealis*, *N. borussicus* and *P. cf. longior* were extracted in a Macfadyen funnel (BIERI *et al.* 1978) from soil cores collected in the summers of 1981 to 1983. *D. diversipilis* originated from laboratory breeding experiments (REUTIMANN 1985). Feeding experiments were conducted in several parallel series according to Table 1.

The dishes for the experiments with *P. borealis*, *N. borussicus* and *P. cf. longior* consisted of several series of burned clay tablets (about 100×150 mm) with small round pits (about 30 mm in diametre and 20 mm deep) (MITTMANN 1980, MITTMANN pers. comm.). They were covered with glass. The individuals could be refound quickly, and faecal pellets could be counted on a small quantity of plant necromass. In all dishes, partly decayed leaves of *D. octopetala*, *C. firma* and *S. coerulea* were used.

Food preferences of all species had been tested in advance with different food qualities. According to these experiments, the macrophytophagous species *P. borealis*, and the panphytophagous species *N. borussicus* and *P. cf. longior* preferred oldest leaves of plant necromass and litter. *D. diversipilis* preferred several fungus species over other microorganisms. This species thus appears to be mainly mycophagous (REUTIMANN 1985).

For *D. diversipilis* another type of dish with a diameter of 6.5 cm allowed the arrangement of 8 discs of malt agar (diameter: 10 mm) overgrown by 7 different fungus species (REUTIMANN 1985). These fungi originated from the natural habitat and had been preferred by adults and all developmental stages from about 60 species of microorganisms. In all dishes, a constant humidity was maintained by small quantities of distilled water.

Temperatures were maintained using water baths and refrigerators. In addition, a climatic chamber was used with daily alternating temperatures (= 15 °C constant temperature for 12 h, 5 °C constant temperature for 12 h, precision: ±0.5 °C, light cycle: 12 h: 12 h). The field experiment were conducted with the same types of dishes implanted into the surface layer of a *Sesleria*-dominated vegetation patch. After two weeks, all individals of the laboratory experiments were removed. The experiments at 5 °C in the laboratory, as well as those under the field conditions described above, were interrupted after 28 days. The faecal pellets were then counted. Quantities of 25 or 50 pellets were collected with a small paint brush, dried in a oven (2 hours at 70 °C) and weighed with a microbalance (Cahn 21, precision: ±1 µg). Egestion rates were then calculated as dry mass of faeces per individual and day. These data were used for calculations of the temperature-dependent increase of egestion rates (Q_{10}) using regression analysis. For estimates of energy budgets, the following formulae were used:

	formula:	citation:
(1)	$C = A + F(U)$	STREIT 1980
	$A \cong C - F$ for ectotherm species	STREIT pers. comm.
(2)	$A = P + R + (U)$	
(3)	$M = L^{1.53} \times B^{1.53} \times 10^{-6.67}$	BERTHET 1964 LEBRUN 1971
(4)	$M = 4/3\ Pi \times L \times B \times H/8$ for Phthiracaridae PERTY, 1841	BERTHET 1964
(5)	$R = 0.161 \times (M \times 10^{-6})^{0.692}$	LUXTON 1975
(6)	$R \cong A/2$	STREIT pers. comm.

C = consumption, A = assimilation, F(U) = faeces (urine), P = production, R = respiration in µg $C \times ind^{-1} \times day^{-1}$ [at 10 °C], M = fresh mass in µg, L = length in µm, B = width in µm, H = height in µm.

For estimates of consumption rates, the following proportions may be assumed using data from the literature (LUXTON 1972, 1979, 1981a, MITTMANN 1980):

(7) A/C for macrophytophagous species: 23—30%
for panphytophagous species: 40—50%
for microphytophagous species: 50—65%

Formulae (1) and (7) were applied to estimate consumption rates, formulae (2) and (5) for estimates of respiration rates on the basis of egestion rates. In addition, formula (2) was used for a third estimate of respiration rates: Egg production was estimated in *D. diversipilis* at 15/5 °C and under seminatural

Table 2. Quantitative aspects of the feeding activity

	1	2	3	4	5	6	7	8	9
P. borealis									
Adults	5	0.46	0.764	0.099	0.396	0.88			
	10	0.262	1.025	0.268	1.072	2.38			0.153
	15	0.554	2.343	1.298	6.192	13.75			
	20	0.395	4.156	1.642	6.568	14.60			
	15/5	0.600	2.321	1.393	5.572	12.40	4.179	2.09	
	field***	0.454	2.308	0.933	3.732	8.29			
N. borussicus									
Larva	15/5	0.231	0.922	0.213	0.469	21.3	0.256	0.128	0.032
Protony	15/5	0.386	2.745	1.060	2.332	55.5	0.272	0.63	0.049
Deutony	15/5	0.550	0.550	1.761	0.969	8.1	1.163	0.582	0.099
Tritony	20	0.336	1.060	0.356	0.783				
Adult	5	0.208	0.322	0.067	0.568	1.46			
	10	0.22	0.82	0.18	0.396	1.02			0.235
	15	0.753	5.21	3.923	8.631	22.13			
	20	0.828	3.116	2.58	5.676	14.55			
	15/5	0.800	2.353	1.882	4.140	10.62	5.642	2.823	
	field***	0.800	3.768	3.014	6.631	17.0			
P. cf. longior									
Adult	5	0.021	0.392	0.021	0.046	1.53			
	15	0.053	1.090	0.051	0.112	3.73			
	20	0.053	1.676	0.088	0.194	6.47			
	15/5		1.184	0.053	0.117	3.9	0.064	0.032	0.044
	field***	0.053	1.090	0.051	0.112	3.73			
D. diversipilis									
Larva	15/5	0.230	0.934	0.215	0.387	69.0	0.172	0.086	0.019
Protony	15/5	0.250	1.341	0.335	0.603	41.0	0.268	0.134	0.033
Deutony	15/5	0.270	1.350	0.363	0.654	29.0	0.291	0.146	0.045
Tritony	15/5	0.175	0.997	0.147	0.314	4.3	0.140	0.070	0.092
Adult	5	0.140	0.550	0.110	0.198	2.0			
	10	0.220	1.153	0.254	0.460	3.3	0.256		0.146
	15/5	0.141	1.590	0.320	0.570	5.9	0.256	0.128	
	15	0.190	1.580	0.300	0.540	5.5			
	17.5	0.200	3.460	0.690	1.242	12.8			
	20	0.200	3.380	0.680	1.224	12.5			
	field*	0.200	2.600	0.520	0.936	9.6			
	field**	0.200	0.900	0.180	0.324	3.3			
	field***	0.200	1.150	0.230	0.414	4.3			
	field****	0.200	0.223	0.045	0.081	0.3			

Explanations: (1) values for constant temperatures within climatic chambers in °C; (2) dry mass per pellet; (3) egestion [pellets $\times$ ind.$^{-1} \times$ d^{-1}]; (4) egestion [μg $\times$ ind.$^{-1} \times$ d^{-1}]; (5) estimated consumption rate [μg $\times$ ind.$^{-1} \times$ d^{-1}]; (6) consumption [percents of dry mass]; (7) estimated assimilation [μg $\times$ ind.$^{-1} \times$ d^{-1}]; (8) respiration rate R_1 [μg C] estimated from egestion rates; (9) respiration rate [μg C] calculated for 10 °C with the formula of Luxton 1975; field (*) July 1983; field (**) August 1983; field (***) September 1983; field (****) October 1983 to June 1984. Further explanations see text.

conditions by counting and weighing eggs. Fresh masses and dry masses were determined by formula (3).

3. Results

The egestion rates of the species are summarized in Table 2 and Fig. 2. Dry masses of faecal pellets as well as egestion rates depended on the experimental temperature. The different fresh masses of individuals of *P. borealis* were responsible for high standard deviations in Fig. 1. Fresh masses of this species ranged between 26.6 and 142.4 μg (formula (4), Table 3).

Table 3. Estimated performances on a population level

	Stage	FM	DM	A	C $m^{-2} \times 75$ d	% of PP
P. borealis	adults	90	45	272	113.7	0.080
N. borussicus	egg	9.7	—	—	—	—
	larva	8.1	2.1	262	9.18	0.008
	protony	17.5	4.9	181	31.73	0.023
	deutony	70.0	19.2	101	16.12	0.012
	tritony	85.8	25.7	60	3.55	0.003
	adults	90.5	28	212	119.75	0.086
P. longior	adults	6	2	625	5.5	0.004
D. diversipilis	egg	1.53	0.7	—	—	—
	larva	2.22	0.56			
	protony	5.18	1.46			
	deutony	8.17	2.25			
	tritony	23.9	7.2			
	adults	42.6	13.2	121	10.13	0.006
total:				**1,834**	**309.65**	0.222

FM: fresh mass in μg; DM: dry mass in μg; A: Abundances, individuals per square-metre; C: Consumption in μg; C/$m^2 \times 75$ d: Consumption of a population per m^2 and 75 days in mg; % of PP-Consumption in percent of the estimated net primary production.

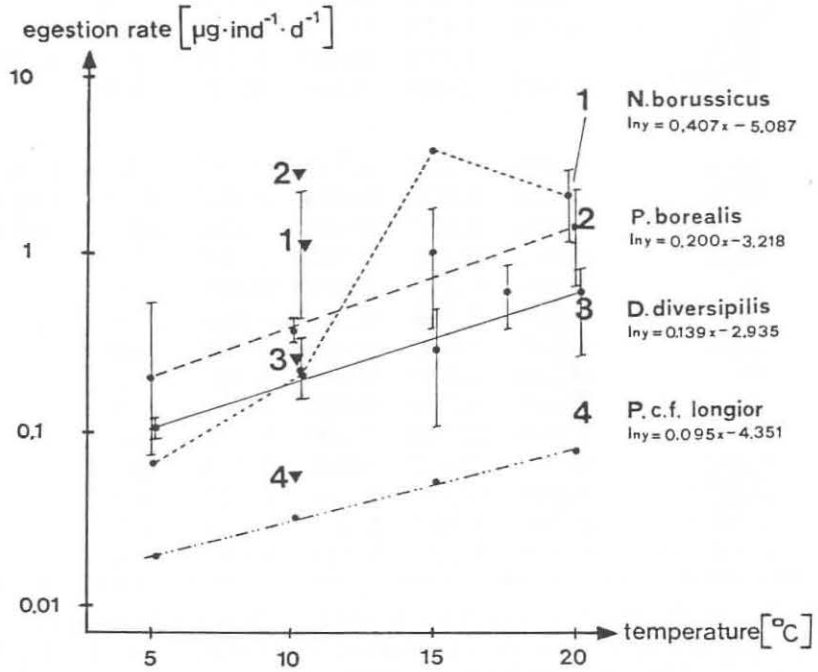

Fig. 1. Temperature dependence of the egestion rate (semilogarithmic graph). ▼ values for 15/5 °C ● values for constant temperatures.

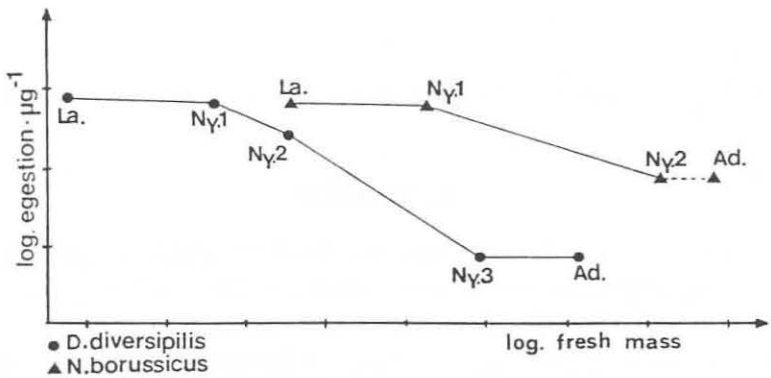

Fig. 2. Relative egestion rates during the life history of *D. diversipilis* and *N. borussicus*.

Table 4. Egg production of *D. diversipilis*

Temperature	Eggs/ind. × d^{-1}	DW × ind. × d^{-1}	% DW (ind.)	% of C
15/5 °C	0.108	0.076	0.5	13.2
s.c. July—Sept.	0.082	0.058	0.4	10.4
s.c. Oct.—June	0.003	0.002	0.01	2.5

s.c.: seminatural conditions (field experiments, REUTIMANN 1985).

Q_{10}-values of egestion rates were estimated for *N. borussicus* as 2.3 [10—15 °C] and 67.5 [5—20 °C], for *P. borealis* as 7.3 [5—15 °C], for *D. diversipilis* as 3.3 [5—15 °C], and for *P. cf. longior* as 2.5 [5—20 °C]. At constant temperatures between 5 and 15 °C, these Q_{10}-values were approximately constant for *P. borealis*, *P. cf. longior* and *D. diversipilis* according to Krogh's curve (comp. STREIT 1980, KOWAL & CROSSLEY 1971), while it is evident from Fig. 1 that the egestion rate of *N. borussicus* was reduced at low temperatures and at 20 °C. On the other hand, daily alternating temperatures of 15/5 °C had a positive effect on egestion rates, when compared with the corresponding values at 10 °C. Also freshly hatched adults of *D. diversipilis* differed from three month old reproductive adults by an increased egestion rate. The values for larvae and nymphae of *D. diversipilis* and *N. borussicus* depended on the individual activity stage. While the absolute values increased until the deutonymphal stage and declined again for tritonymphae and adults, the specific egestion rates (per fresh mass) decreased constantly during ontogeny in both species (Fig. 3). Mean values of fresh masses, dry masses and abundances in 1982 and 1983 are given in Table 3.

The egg production rates of *D. diversipilis* were estimated from cultures (REUTIMANN 1985) and are shown in Table 4.

According to Tables 2 and 4 and formula (2) R may be estimated from egg production and assimilation as

$$R_3 = 0.256 - 0.076 = 0.18\,\mu g \times ind.^{-1} \times d^{-1}.$$

This value may be compared with R_1 and R_2 in Table 2.

4. Discussion

The two main macrophytophagous feeders *P. borealis* and *N. borussicus* exhibit higher absolute consumption rates. Their Q_{10}-values are also higher. This indicates a stronger temperature dependence, particularly in the range of low temperatures. MITTMANN (1980) found slightly lower Q_{10}-values of egestion rates for *Nothrus* sp. and *Phthiracarus piger* SCOPOLI, 1763 (2.3 and 3.0), but his values for *Damaeus onustus* KOCH, 1841 and *D. clavipes* (HERMANN, 1804) (3.02 and 2.9) are well comparable with those of *D. diversipilis*. The panphytophagous species *P. cf. longior* had the lowest Q_{10}-value. It may be suggested that panphytophagous species with low Q_{10}-values may be well adapted to the strongly alternating temperature regime of alpine conditions. The relative consumption data of *D. diversipilis* and *P. cf. longior* ranged in a similar order as the literature values for microphytophagous species (5.5—9 %, LUXTON 1972; 7 %, MCBRAYER & REICHLE 1971). On the other hand, the percentages of *P. borealis* and *N. borussicus* were relatively low when compared with the values of some lowland mites (MITTMANN 1980, comp. Table 5). Respiration values for *D. diversipilis*, obtained by three different methods, are in a similar range. Slightly lower values of R_3 may be due to the fact that the measured egg production is only one of several production performances. Storing of fat reserves may not be an important factor in the energy budgets of Belboidea DUBININ, 1958 as WALLWORK (1973) suggests. Other production activities are e.g. production of spermatophores in males, and production of pheromones in both sexes. These factors may also be responsible for the fact that Belboidea are classified by LUXTON (1981) into the group with $R < P$.

Alternating temperatures have a positive effect on egestion rates and probably also on consumption mainly in the macro- and panphytophagous species. There is no evidence that

Table 5. Consumption, assimilation and egestion values in the literature

		C (μg/ ind × d)	C % DM	A % DM	A/C	Fresh mass	Dry mass	Egestion μg/ind × d	Egestion % DM	Temp./Author	
Damaeus clavipes	(m, f)	5.80	5.144	3.16	61.5	200	69.4	2.2	3.17	15	Luxton 1972
	(tri)	1.49	3.14	1.47	61.5	100	24.8	0.79	3.19	15	Luxton 1972
	(deu)	0.72	4.0	2.63	65.7	50	10.3	0.25	2.43	15	Luxton 1972
	(pro)	0.39	5.14	3.25	63.37	25	4.3	0.14	3.26	15	Luxton 1972
D. clavipes		10.8	11.3		39.2	202.3	95.6	7.6	7.95	10	Mittmann 1980
D. onustus		15.6	5.76		48.9	423.7	271.0	8.7	3.21	10	Mittmann 1980
D. diversipilis	(m, f)	0.57	5.9	1.92	57 ass.	42.65	13.32	0.32	2.4	15/5	present study
	(tri)	0.314	4.3	1.05	57 ass.	23.9	7.2	0.147	2.04	15/5	present study
	(deu)	0.654	29	2.18	57 ass.	8.17	2.25	0.363	16.1	15/5	present study
	(pro)	0.603	41	2.01	57 ass.	5.18	1.46	0.335	22.9	15/5	present study
	(la)	0.387	69	1.29	57 ass.	2.22	0.56	0.215	38.4	15/5	present study
Nothrus borussicus		4.1	9.1	12.5	45 ass.	90.5	45	1.882	4.2	15/5	present study
N. silvestris		3.9	6.9	3.33	48.3	56.5	26.3	0.9—1.4	3.5—5.4	10	Thomas 1979
Nothrus spec.		17.2	60.5		22.67	42.4	28.4	13.5	47.6	10	Mittmann 1980
Platynothrus peltifer		4.6	7.7	3.57	46.3	59.8	27.2	1.23	4.5	10	Thomas 1979
Steganacarus magnus			1.0	0.12	12.0	300		38.0		22	Berthet 1964
— (mature males)		6.29	2.85	0.54	19.1	183		5.08		18	Webb & Elmes 1972
— (newly moulted males)		8.60	4.05	2.36	58.3	176		3.59		18	Webb & Elmes 1972
— (mature females)		6.81	1.4	0.74	52.9	448		3.21		18	Webb & Elmes 1972
— (newly moulted females)		15.2	3.6	2.09	58.1	362		6.34		18	Webb & Elmes 1972
Phthiracarus piger		56.2	41.47		28.88	317.5	135.5	43.3	31.9	10	Mittmann 1980
P. reticulatus		44.3	34.8		22.69	235.6	127.3	36.4	28.6	10	Mittmann 1980
P. borealis		5.57	12.4	9.29	26 ass.	90	45	1.39	3.09	15/5	present study
Protoribates cf. longior		0.117	3.9	2.1	45 ass.	6	3	0.117	1.95	15/5	present study
Oribatulidae			1.7								

Note: DM = Dry Mass

assimilation may be diminished under these conditions. According to MITTMANN (1980), it depends on the environmental temperature. Egestion was influenced by the individual life stage and by the physiology (activity, moulting, reproduction).

In the laboratory and in the field, *P. borealis*, *N. borussicus* and *P. cf. longior* exhibited a smaller percentage of plant materials in the gut contents at low temperatures (REUTIMANN 1985. comp. ANDERSON 1975, 1977), this indicates a change of feeding type (after LUXTON 1972). Many individuals may change their feeding preferences within several hours and tend to be panphytophagous feeders with a major preference for microorganisms (REUTIMANN 1985). The artificially high Q_{10}-values of these species observed under laboratory conditions can thus be explained by the fact that microorganisms were rare in the experiments. The individuals were therefore forced to feed on plant litter. Generally, the nutrition of macro- and panphytophagous microarthropods may depend also on the litter quality, e.g. on its colonisation with microorganisms and its degree of decomposition (comp. MITTMANN 1980, ANDERSON & BIGNELL 1983, GOURBIERE *et al.* 1985).

Particularly in *Carex firma*, nitrogen content of the plant residues is relatively low (GALLAND 1982). In consequence, A/C-quotients may not be a constant species-specific value. In addition, smaller oribatid species such as *P. cf. longior* cannot be mainly macrophytophagous (MITTMANN 1980). These smaller species predominate in alpine ecosystems (SCHATZ 1978, 1979; MATTHEY *et al.* 1981; REUTIMANN 1985). The Q_{10}-values of these mainly panphytophagous and microphytophagous species may be rather lower under natural conditions, when enough microbial food is present. The egestion rates of all species are not directly comparable with the values of lowland species (Table 5). Absolute consumption rates are derived values and give only a rough estimate.

For estimates of the influence of oribatid mites on nutrient fluxes in an ecosystem, the quality of the performances may also be of particular interest. Feeding marks on dead leaves and feeding preferences may be regarded as a promotion of microbial infections. Spores may be distributed (MIGNOLET 1971, REUTIMANN 1985) to new substrates in faeces. Aggregative behaviour, as regularly observed e.g. in *P. cf. longior* may have another important additive effect on the decomposition of organic materials in confined microhabitats (REUTIMANN 1985).

Mites may be of particular importance for the nutrient cycle of critical elements (comp. MCBRAYER 1977, LUXTON 1979). GALLAND (1982) pointed out that accumulations of phosphorus, nitrogen and potassium can occur in old parts of vegetation like the stems of *Dryas octopetala* or in dead structures which all represent good food substrates for mites.

During the individual life span of *N. borussicus* and *D. diversipilis* the relative egestion rates decrease. These stages may therefore exhibit an important contribution to the degradation of organic materials. On the other hand, freshly hatched adults and reproductive females may also have a major contribution on the nutrient fluxes as our experiments with *D. diversipilis* suggest. WEBB & ELMES (1972) point out changes of similar range for adults of *Steganacarus magnus* (NICOLET, 1855).

At the population level, consumption rates of the 4 species m^{-2} were roughly estimated to be 309 mg (5.5—180 mg for each species). Compared with the net primary production of 140—160 g m^{-2} in the alpine meadow (GALLAND 1982) this may be only 0.22 % (0.004—0.13 for each species). Even if we assume that these species represent less than 30 % of total oribatid biomass, the performance of oribatid mites may be lower than comparable values of lowland populations (0.44—1.1 % of the net primary production, comp. KOWAL & CROSSLEY 1971, THOMAS 1979, LUXTON 1981b).

On the other hand, the delayed decomposition of organic materials as stated by GALLAND (1982) is responsible for a major change of microclimatic conditions (FRIES 1985) and therefore for a direct promotion of soil organisms.

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6. Résumé

[Aspects quantitatifs de la nutrition de quelques Acariens Oribates (Oribatida, Acari) dans un écosystème de prairie alpine]

L'aspect quantitatif de la nutrition de quelques Acariens Oribates a été étudié dans une prairie alpine (Caricetum firmae Kerner [Br.-Bl. 1926]) au Parc National Suisse.

Les poids journaliers de fécès (p. j. f.) produits par μg d'individu ont été mesurés en laboratoire ainsi que dans le biotope d'étude et ont servi à estimer les budgets énergétiques de *Phthiracarus borealis*, *Nothrus borussicus*, *Protoribates cf. longior* et *Damaeus diversipilis*. A cette fin, les quotient A/C ont été estimés selon les différents types de nutrition des espèces. La respiration de *D. diversipilis* a été déterminée par trois méthodes différentes.

Les p. j. f. sont inférieurs à ceux d'espèces apparentées des plaines; ceci en raison des poids individuels bas. Les valeurs Q_{10} du p. j. f. de *P. borealis* et de *N. borussicus* sont fortement élevées. Les températures journalières alternantes influencent le taux de fécès ainsi que la consomption de manière positive. Les rejets produits mis en relation avec le poids individuel de *D. diversipilis* et de *N. borussicus* diminuent pendant l'ontogenèse individuelle.

Les populations des quatres espèces étudiées constituent près de 30% de la biomasse de tous les Acariens Oribates du biotope étudié. Mais elles ne participent qu'à 0,22% à la destruction de la litière qui s'accumule annuellement. D'autre part, cette destruction retardée a l'avantage d'augmenter la diversité des microhabitats.

7. References

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Synopsis: *Original scientific paper*

Reutimann, P., 1988. Quantitative aspects of the feeding activity of some oribatid mites (Oribatida, Acari) in an alpine meadow ecosystem. Pedobiologia **31**, 425—433.

Quantitative feeding studies were performed on the dominant and frequent mite species *Phthiracarus borealis*, *Nothrus borussicus*, *Protoribates cf. longior* and *Damaeus diversipilis* of an alpine meadow ecosystem of the Swiss Alps (2,550 m above sea level) in laboratory and field experiments.

Egestion rates were determined by counting and weighing faecal pellets. Assimilation and consumption values were then estimated under assumption of A/C-quotients according to their feeding types. Respiration was determined for *D. diversipilis* by three different methods. The absolute egestion rates were lower than comparable values of lowland species in part due to their smaller body sizes. Q_{10}-values were high. Daily alternating temperatures had a stimulating effect on egestion rates. During ontogenesis, relative egestion rates were decreased. The four species only consume 0.22% of the annual primary production of the alpine meadow.

Key words: oribatid mites, Alpine meadow ecosystem, *Phthiracarus*, *Nothrus*, *Protoribates*, *Damaeus*, energy budgets, egestion, feeding types, decomposition, nutrient cycles.